Social Dynamics and Activity Patterns of Bottlenose Dolphins, *Tursiops truncatus*, in Jervis Bay, Southeastern Australia

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Group characteristics, activity patterns, and the occurrence of recognisable bottlenose dolphins were documented from boat surveys conducted in Jervis Bay between May 1997 and April 1998. Bottlenose dolphins were found to occur in the bay year-round, with group size ranging from a single animal up to 64 individuals (x = 15.3, SD = 14.2; median = 9, interquartile range = 18). Calves were observed during all seasons, and group size was positively correlated to the number of calves in the group. Newborns were observed only in summer and autumn. Group size was significantly different according to activities, being smaller during feeding, and larger during socialising. The most frequently recorded group activity was travelling, followed by feeding, milling and socialising. The frequency of activities changed according to season, with an increase in travelling from winter to summer and autumn, and an increase in feeding in winter and spring. A total of 103 individual dolphins were identified, with most seen in the bay either year-round or only within one season.

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INTRODUCTION

Patterns of social organisation of bottlenose dolphins, *Tursiops truncatus*, appear to be quite complex, with groups frequently changing size and composition (eg. Ballance 1990; Shane 1980; Würsig 1978). From earlier reports, habitat structure and activity patterns appear to be the main factors influencing group size, while group composition appears to be primarily based on age and sex of the individuals (eg. Shane et al. 1986; Smolker et al. 1992; Wells et al. 1987).

Bottlenose dolphins are found in all temperate and tropical waters around the world (Leatherwood and Reeves 1983). In Australia they occur throughout all nearshore waters (Ross and Crockcroft 1990), but detailed information on populations is available for only a few areas (eg. Connor and Smolker 1985, Smolker et al. 1992 for Shark Bay, WA; Corkeron 1990, 1997, Lear and Bryden 1980, for southeast QLD; Mandelc and Fairweather 1995 for Jervis Bay, NSW). Dolphin groups in Australian waters range from a mean size of only approximately 5 animals in Shark Bay, WA to about 16 off Stradbroke Island in Queensland (Corkeron 1997; Smolker et al. 1992). In Shark Bay, group size varied significantly with activity, being larger for socialising than for resting and travelling groups (Smolker et al. 1992). About 70 of these animals appear to show year-round residency near Monkey Mia in the east of the bay (Smolker et al. 1992). In Jervis Bay, approximately 200 km south of Sydney, an earlier study reported that a small group of bottlenose dolphins, which appeared to belong to a larger population, used the area as their core home range (Mandelc and Fairweather 1995).

In this paper we report initial findings from an investigation of the social structure and dynamics of these bottlenose dolphins in Jervis Bay. Specifically, we document group characteristics, activity patterns and the occurrence of recognisable individuals.

MATERIAL AND METHODS

Jervis Bay (35°07′S, 150°42′E) (Fig.1) is a relatively enclosed embayment with 102 km^2 of water surface, characterised by shallow waters, which gradually slope towards the entrance, with maximum depths reaching approximately 30 m (West 1987; Cho 1995; Holloway 1995).

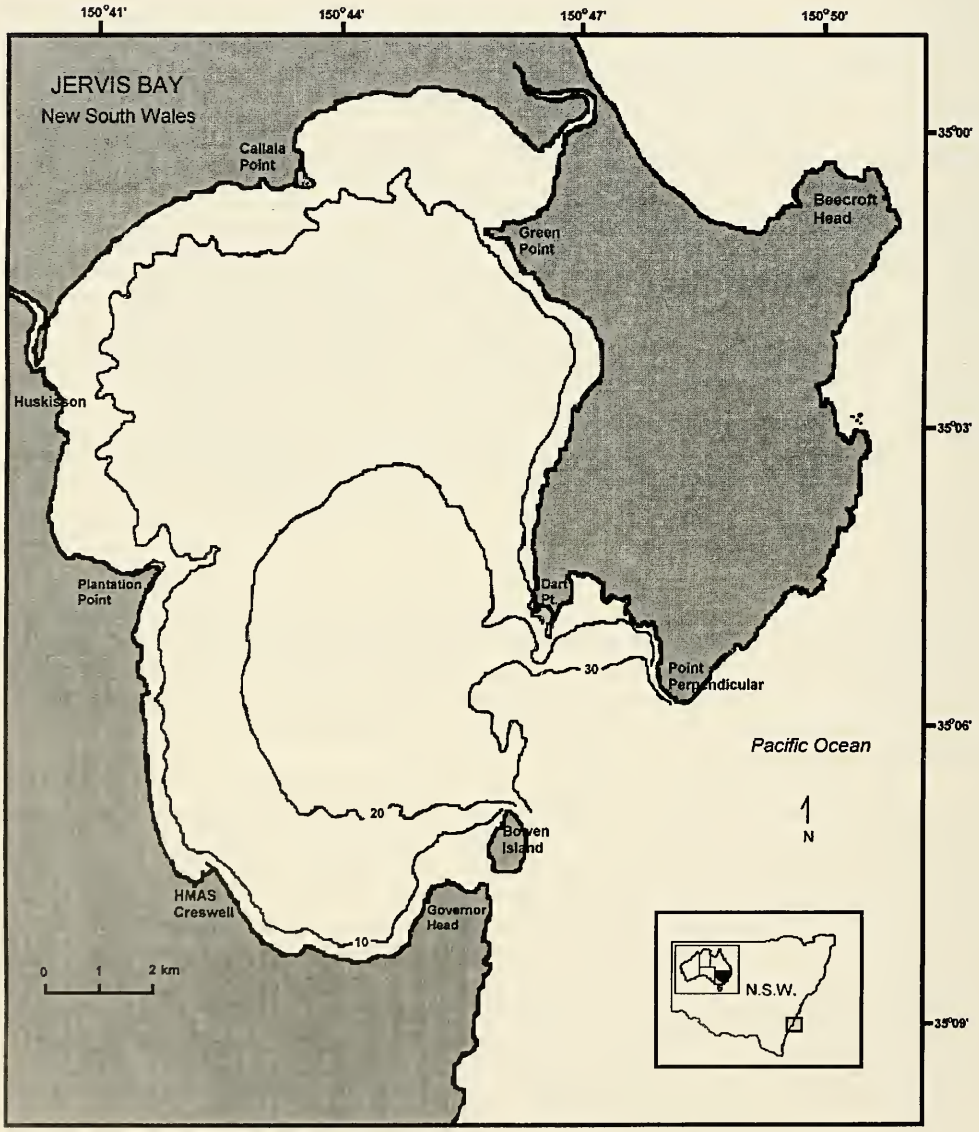

Figure 1. Map of Jervis Bay, New South Wales, Australia, showing 10 and 20 m depth contours.

Between May 1997 and April 1998, we conducted a total of 51 boat surveys in the area, for approximately 303 h of survey time and 3645 km of water surface surveyed. Routes were concentrated along the periphery of the bay, approximately along the 10 m isobath, coupled with transects crossing the middle of the bay. Consecutive survey routes in the periphery were alternated between clock-wise and anti-clock-wise directions. Effort was directed towards circumnavigating the whole bay each day with an additional transect in the middle of the bay, but surveys were curtailed or direction altered if conditions changed to a Beaufort Sea State 4 or greater. A bias towards the periphery of the bay was chosen for sampling because in a previous study dolphins were found to use waters less than 11.4 m deep nearly 90% of the time (Mandelc and Fairweather 1995). During each survey the sea was scanned 90 degrees from the bow and to each side of the boat forward of the midline (with one observer on each side) to search for dolphin groups.

When a dolphin group was encountered we recorded time of sighting, observed activity, estimated group size (including the presence and absence of calves and newborns), and attempted to photograph each individual's dorsal fin. Groups were defined as animals sighted within an area of approximately 100 m radius (Irvine et al. 1981). Calves were defined as animals between one half to two thirds the length of an adult, and newborns as individuals less than one half the size of an adult. Size comparisons could be made because both calves and newborns usually spend a significant amount of time in very close proximity to an adult. Group size was estimated by several visual counts conducted by the boat crew during the sighting. Group sizes are presented as both means and medians. Mean group sizes are presented in order to facilitate comparisons with other bottlenose dolphin studies, while medians are presented because the distribution of group size was skewed and sample sizes were relatively small. Activity patterns were defined according to Hanson and Defran (1993) and Shane (1990a) with five mutually exclusive categories: travelling, feeding, socialising, milling, and resting. Travelling groups were characterised by a uniform directional movement, with a rhythmic surfacing pattern. Feeding groups were distinguished by variable directional movement with frequent rapid dives, often exposing the fluke or tail stock. Socialising groups presented variable directional movement with body contact and splashing among individuals, and various displays and leaps. Milling groups also moved in variable directions, staying close to the surface without showing apparent surface behaviours and body contact. Resting groups were defined as animals floating or moving very slowly, with no wake observed. Activity was recorded over a 3-min interval at the time of initial sighting of a particular group (Altmann 1974). During this initial observation period, the boat remained at least 30 m from the group, in order to minimise disturbance. After this period we approached the group slowly and kept a distance of about 10 m to facilitate photo-identification of individuals. Attempts were made to photograph every member of the group at each sighting. Natural marks on the trailing edge of the dorsal fins were used to identify individual dolphins (Würsig and Jefferson 1990; Würsig and Würsig 1977).

Seasons of the year were divided as follow for analyses of seasonal occurrence of calves and newborns, and seasonal frequency of activities: autumn from March to May; winter from June to August; spring from September to November; and Summer from December to February.

RESULTS

Group characteristics

Bottlenose dolphins were observed in the bay year-round, with a total of 101 groups sighted and 1540 individuals counted. Groups varied from a single animal up to 64 individuals (Fig. 2). Mean group size was 15.3 animals (SD = 14.2) and median group size was 9 (interquartile range = 18.0).

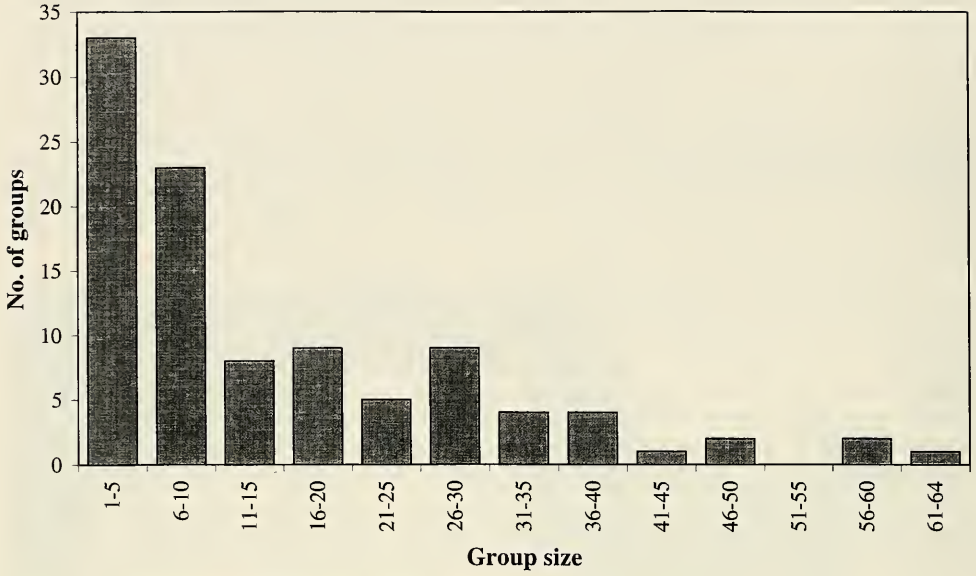

Figure 2. Frequency distribution of group size of bottlenose dolphins in Jervis Bay.

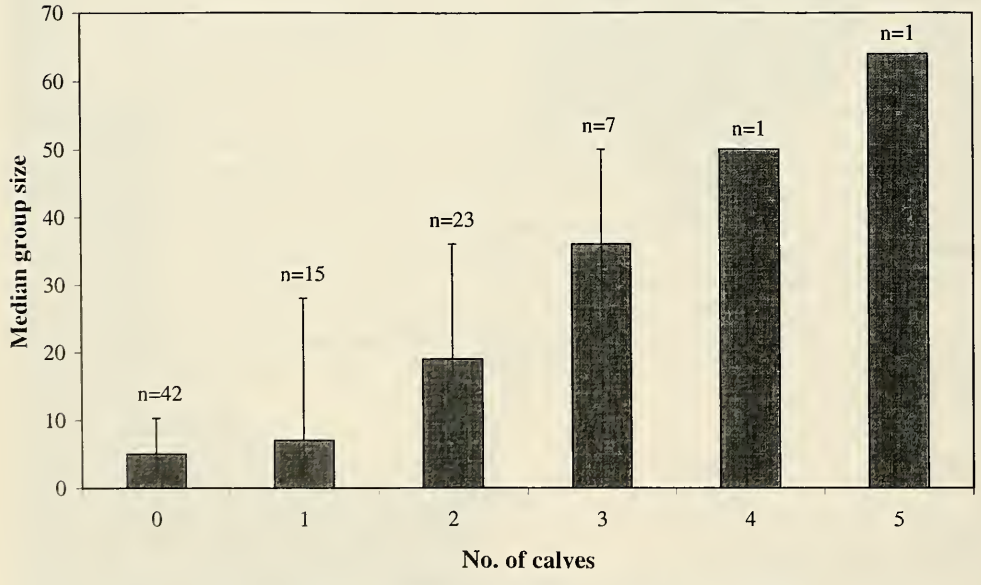

Figure 3. Bottlenose dolphin group size by number of calves seen in the group in Jervis Bay.

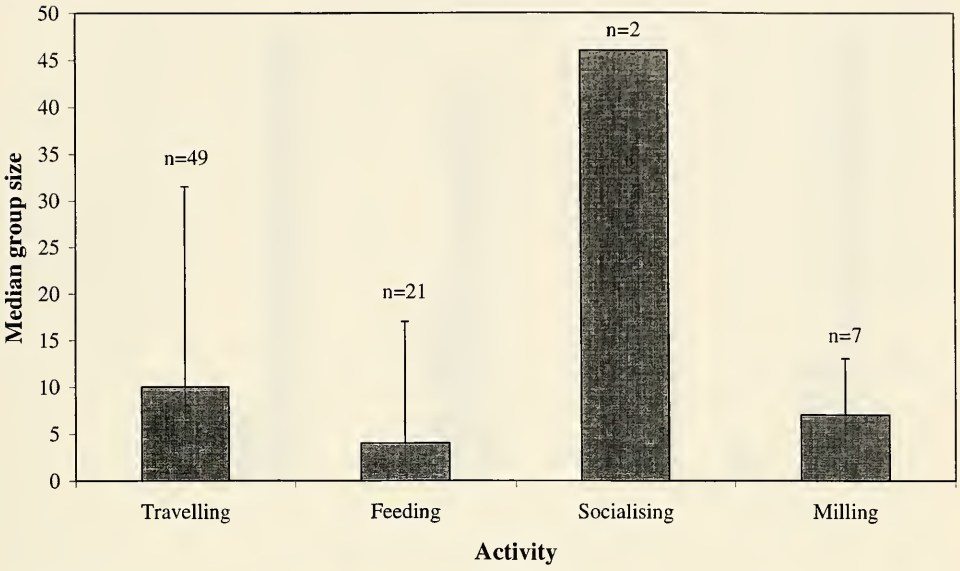

Figure 4. Bottlenose dolphin group size according to activities in Jervis Bay.

Calves were observed during all seasons, composing 5.9% (n = 91) of sighted animals. A minimum of one and maximum of five calves were observed per group. Group size was positively correlated with the number of calves in the group (Spearman $r^2 = 0.41$, $p < 0.01$, n = 89) (Fig. 3).

Newborns were observed only in summer (n = 3) and autumn (n = 1), and constituted only 0.3% of dolphins sighted during the year. On two separate occasions a single newborn was observed in a group (group sizes = 21 and 64), and once, two newborns were recorded in a group (group size = 8).

Group size varied significantly with activity (Kruskal-Wallis, $p < 0.05$, n = 79). Group size was usually larger for socialising, than for travelling, milling, and feeding groups (Fig. 4). Resting groups were never observed during the 3-min interval at the beginning of a sighting.

Activity patterns

Travelling was the group activity most frequently observed (61%), followed by feeding (29%), milling (8%) and socialising groups (4%). The frequency of travelling increased from winter to spring, summer and autumn, while feeding was more frequently observed in winter and spring (Fig. 5). Milling was not observed in spring and autumn, and socialising was only observed in summer and autumn.

Photo-identification

A total of 5796 photographs were taken, from which we identified 103 individual dolphins. The number of sightings of each of these animals varied from one to 27 (Fig. 6), with a mean of 9.6 (SD = 8.1) and median of 7 (interquartile range = 16.0). Forty-nine animals (48% of identified dolphins) were observed in the Bay at least once during each season. Thirty-seven individuals were observed in just one season (36%), 9 dolphins were observed during two seasons (9%), and 8 dolphins were observed during three different seasons (8%).

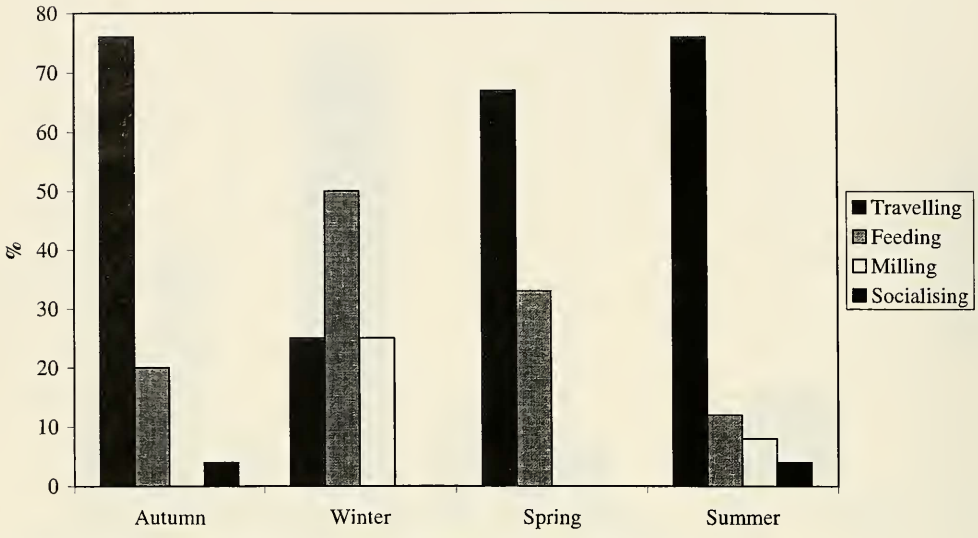

Figure 5. Frequency of activities of bottlenose dolphins by season in Jervis Bay.

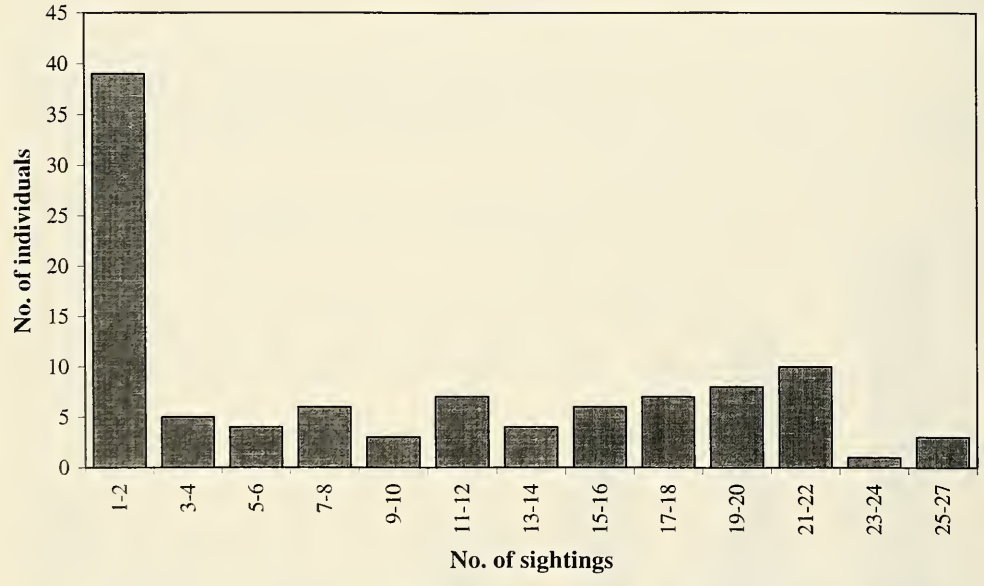

Figure 6. Frequency distribution of the number of sightings of each photo-identified bottlenose dolphin in Jervis Bay.

DISCUSSION

The size of bottlenose dolphin groups in different areas of the world is highly variable. Mean group sizes range from about 5 individuals (Irvine et al. 1981; Smolker et al. 1992; Weigle 1990) up to 140 animals (Saayman and Tayler 1973). Bottlenose dolphins in Jervis Bay coalesce in groups whose mean size is similar to those of California and southern Queensland (Ballance 1990; Corkeron 1997), but larger compared to those in Florida,

Western Australia, and the Mediterranean (Bearzi et al. 1997; Smolker et al. 1992; Wells et al. 1987). While some differences in group size may be related to different definitions of exactly what a group is, it has been proposed that small groups usually occur in shallow protected habitats while large groups occur in open and deep habitats (reviewed in Shane et al. 1986, though see Scott and Chivers 1990). Bottlenose dolphins in Jervis Bay are usually found in waters less than 11.4 m deep (Mandelc and Fairweather 1995), but group size is relatively large. Predation avoidance and facilitation of location, herding and capture of schooling fish have been suggested as the main determinants of the formation of large dolphin groups (Norris and Dohl 1980; Shane et al. 1986; Wursig 1986). Large predatory sharks are not known to commonly occur in Jervis Bay (Pollard 1973; R. Chan in litt.) and cooperative feeding is rarely observed (L. Möller pers. obs.), therefore neither of these hypotheses are likely to explain the large size of groups found in the area.

In Jervis Bay approximately one half of identifiable dolphins were present in all four seasons. Hence, there is apparently a resident community of bottlenose dolphins in the area. Another one third of the dolphins identified in the Bay were seen in only one season, suggesting that the resident community may receive frequent visits of transient animals from outside. In chimpanzees, group size may increase in the peripheral areas of the community range, where encounters with individuals from neighbouring communities are most likely to occur, suggesting a defensive response by resident groups to avoid intraspecific aggression from neighbouring groups (Symington 1990). Whether a similar mechanism is operating with Jervis Bay dolphins remains to be tested.

The increase in group size with an increase in the number of calves in the group, as observed in Jervis Bay and other bottlenose dolphin populations (eg. Bearzi et al. 1997; Weigle 1990; Wells et al. 1987), has been related to potential advantages of enhanced calf assistance, protection and reduced maternal investment (Norris and Dohl 1980). However, a decrease in group size for feeding, as observed in Jervis Bay, may indicate that those benefits could be counterbalanced by reduced feeding efficiency, and that higher rates of food intake may usually not be gained through those large groups (Bearzi et al. 1997).

Observations of newborns in summer and early autumn indicate calving in Jervis Bay occurs during this period. This reflects a general pattern observed elsewhere, with calving occurring during the warmer months (Fernandez and Hohn 1998; Gruber 1981; Scott et al. 1990; Urian et al. 1996; Weigle 1990). From vessel-based work in coastal waters of southern Queensland, calves were observed in all months of the year and newborns more frequently in summer (P. Corkeron, in litt.), while from aerial surveys calves were not observed from January to March (Lear and Bryden 1980). It is possible that observers from altitude did not see calves and newborns because of their small size.

The overall activity budget of the Jervis Bay bottlenose dolphins is not dissimilar to those elsewhere, with travelling being the most frequent activity, feeding intermediate and socialising relatively infrequent. We found that there was a substantial increase in feeding in the cooler months. There are other populations worldwide that also show an increase in time spent feeding during the coldest seasons as observed for the Jervis Bay dolphin population (eg. Gruber 1981; Shane 1990b). The increase in feeding in the cooler months has been hypothesised to be related to an increase in energetic requirements with decreases in water temperature and/or to changes in prey abundance (Bräger 1992; Shane 1990a). Water temperature in Jervis Bay decreases from a mean of 22.5° C in February to a mean of 14.5° C in August (Cho 1995). Given that most species have a Q_{10} metabolic rate of 2, and that a decrease in temperature of nearly 8 degrees equates to almost a doubling of metabolic rate (Gaskin 1982), it is not unreasonable to assume increased feeding requirements in the cooler months.

The presence of newborns in Jervis Bay only during summer and autumn, considering that the gestation period of bottlenose dolphins is approximately one year (Perrin and Reilly 1984), suggest that mating in the area occurs during this time of the year.

Coincidently socialising, which has been hypothesised elsewhere to relate to calving and mating (Hanson and Defran 1993), was observed in Jervis Bay only during these seasons.

A highly variable number of sightings per individual indicate differential use of the bay by the animals, but the re-sightings of 48% of identified dolphins at least once during each season suggest that many are resident in the area. Furthermore, 36% of identified dolphins were composed of individuals observed inside the bay in only one of the four seasons, suggesting that a significant number of animals may visit the area only sporadically. While there is a possibility of simply failing to sight them, the hypothesis of migration of dolphins from the open ocean to the coast and/or from coastal waters outside Jervis Bay cannot be rejected .

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